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Nurses' Knowledge and Practices Regarding Safe Drinking Water and Waterborne Diseases: Clinical Risk Assessment, Infection-Control Education, Environmental Health Surveillance, Community-Based Prevention, and Hospital Nursing Interventions

Ahmed Mufleh Alenazi[1], Fatimah Muidh Alshehri[2], Ibrahim Abdullah Al Saweed[3], Abdullaziz Mohammed Alkhamali[4], Aozouf Fraj Abdullah Alosaimi[5], Ahmed Abdullah Altowairqi[6]

[1] CT Scan Technologist,

[2] PharmD,

[3] Social Services,

[4] Social Worker,

[5] Pharmacy Ministry of National Guard Health Affairs

[6] Nephrology King Abdulaziz Specialists Hospital

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ABSTRACT

Safe drinking water is fundamental to health. Nurses occupy pivotal positions at the intersection of clinical care, infection prevention and control (IPC), environmental health surveillance, and community outreach; they are uniquely positioned to prevent, detect, and respond to waterborne disease. However, knowledge gaps and variability in practices among nursing staff compromise risk mitigation at individual, facility, and population levels. Nurses are essential actors across the continuum of water safety: prevention, surveillance, clinical management, outbreak response, and education. The complexity of waterborne disease prevention demands that nursing roles extend beyond bedside care to active participation in environmental surveillance, Water Safety Plan (WSP) implementation, and public health coordination. Nurses bring clinical insight into risk assessment (identifying vulnerable patient groups such as neonates, oncology and transplant patients, and those with indwelling devices), operational knowledge of point-of-use (POU) device workflows, and frontline experience with early clinical signals that often precede laboratory confirmation. Evidence from hospital-based programs demonstrates that integrated clinical–environmental approaches — for example, routine microbiologic monitoring coupled with targeted patient surveillance — reduce the incidence and duration of water-related healthcare-associated infections (HAIs) and outbreaks by enabling earlier corrective action and targeted prophylaxis.

Keywords: Nursing; Waterborne Diseases; Drinking Water Safety; Infection Prevention and Control; Water Safety Plan; Environmental Surveillance; Point-of-use; Outbreak Investigation; Disaster Response.

INTRODUCTION

Safe drinking water is a cornerstone of public health. Despite substantial progress globally, contaminated drinking water remains a major source of morbidity and mortality, particularly through diarrheal diseases, but also through respiratory, cutaneous, systemic, and toxin-mediated illnesses (World Health Organization [WHO], 2017; Prüss-Ustün et al., 2014). Water can transmit a broad spectrum of pathogens (enteric bacteria such as Escherichia coli, Shigella and Salmonella; viruses including norovirus, rotavirus and hepatitis A/E; protozoa such as Giardia and Cryptosporidium; and Legionella spp. in engineered water systems), as well as chemical hazards (arsenic, lead, fluoride) and biological toxins (cyanotoxins). Clinically, these exposures produce an array of manifestations from acute watery diarrhea and severe dehydration (e.g., cholera) to pneumonia (regionalisms), chronic neurodevelopmental and renal injury from heavy metals, dermatoses associated with cyanotoxin exposure, and systemic sepsis from opportunistic organisms in compromised hosts.

Nurses constitute the largest single professional group within healthcare systems and play pivotal roles in reducing the burden of water-related disease across settings. Their clinical responsibilities extend beyond bedside care to preventive, surveillance, educational, and managerial domains. At the bedside, nursing assessment must integrate water-related risk factors into routine history-taking and physical examination: travel and recent water exposures, household water sources and treatment practices, stool frequency and characteristics, signs of moderate-to-severe dehydration (tachycardia, hypotension, delayed capillary refill), sepsis screening for invasive infection, and neurologic or developmental milestones suggestive of chronic toxic exposures. Objective measures—daily weights, fluid balance charts, urine output, and laboratory indices (electrolytes, creatinine, inflammatory markers)—guide management of dehydration and organ dysfunction.

Evidence from systematic reviews and randomized trials demonstrates that household and health-facility water interventions reduce diarrhoeal disease and child mortality; point-of-use (POU) treatment (chlorination, filtration, solar disinfection) and safe storage consistently lower microbial contamination and disease incidence when correctly implemented and maintained. In healthcare settings, implementation of Water Safety Plans (WSPs)—a risk-management approach endorsed by WHO—has been associated with reduced water quality incidents and outbreak frequency when multidisciplinary teams enforce system assessment, operational monitoring, verification and communication. Nurses are essential members of these teams, bringing clinical perspective to hazard identification, prioritization of risks for vulnerable patient groups (neonates, the elderly, the immunocompromised), and the translation of monitoring data into clinical action.

Practical nursing interventions include: promoting and modeling strict hand hygiene and point-of-care infection prevention for all procedures involving water; ensuring use of sterile or appropriately treated water for wound care, enteral feeding, and medication reconstitution; screening patients for water-related exposures and escalating concerns to infection control or public health; and delivering targeted education to patients and caregivers on safe water storage (narrow-neck containers, tap spouts), household treatment options (correct dosing and contact time for chlorine, maintenance of ceramic or membrane filters, guidelines for solar disinfection), and indicators of severe illness. Nurses should be proficient in simple water-quality verification: recognizing turbidity's impact on disinfection efficacy (target turbidity <1–5 NTU depending on context), understanding the meaning of free residual chlorine (WHO recommends ~0.2–0.5 mg/L at point of use for distribution systems), and knowing when to seek laboratory microbiology or environmental engineering assessment.

In outbreak or emergency response, nurses lead case finding, triage, cohorting, and implementation of provisional water-safety measures—distribution of safe drinking water, provision of POU supplies, and coordination with supply chain to ensure sustainable interventions. Within hospitals, nursing leadership can spearhead WSP implementation: participating in hazard analysis of plumbing systems (hot-water storage, dead legs, aerosol-generating equipment), developing routine operational monitoring protocols (temperature, residual disinfectant, turbidity), and instituting escalation pathways for breaches. Nursing-led quality improvement projects have effectively reduced water-associated healthcare-associated infections (e.g., Pseudomonas and Legionella) by instituting point-of-use filters for high-risk wards, standardized device reprocessing using validated water quality, and staff education.

Professional development should incorporate environmental health competencies—interpretation of water-quality data, risk communication, and interprofessional collaboration with microbiology, engineering and public health. By integrating clinical vigilance, evidence-based bedside practice, community education, and organizational leadership, nurses can substantially reduce the morbidity and mortality attributable to contaminated drinking water and strengthen health system resilience against water-related hazards.

1. 1. PATHOGEN PROFILES AND ENVIRONMENTAL HAZARDS

1.1. Enteric bacterial

Enteric bacteria remain among the most clinically significant waterborne pathogens. Pathogenic Escherichia coli strains (enterotoxigenic E. coli [ETEC], enteropathogenic E. coli [EPEC], enterohemorrhagic E. coli [EHEC]) produce distinct toxins and virulence factors that determine clinical syndrome and management. ETEC causes secretory diarrhoea mediated by heat-labile and heat-stable enterotoxins; EHEC (notably O157:H7) produces Shiga toxin and is associated with bloody diarrhoea and risk of hemolytic uremic syndrome (HUS). Clinical nursing implications include early recognition of signs of HUS (pallor, oliguria, petechiae), close monitoring of urine output, serial haemoglobin/platelet/creatinine measurements, and rapid liaison with nephrology for potential dialysis. Importantly, antibiotics are generally contraindicated in suspected EHEC due to increased HUS risk; nurses play a key role in antimicrobial stewardship by ensuring cultures are obtained before empiric therapy when feasible.

Vibrio cholerae causes profuse, watery "rice-water" diarrhoea and can precipitate hypovolaemic shock within hours. WHO and clinical guidance emphasize early aggressive rehydration: oral rehydration solution (ORS) for most patients and intravenous crystalloids (e.g., Ringer's lactate) with bolus dosing guided by clinical signs in severe dehydration. Nurses perform frequent vital sign monitoring, orthostatic assessments, strict intake/output charting, and rapid initiation of rehydration protocols; placement of urinary catheter for accurate output measurement may be necessary. Doxycycline or azithromycin can shorten disease duration in some cases; public health notification and source investigation are mandatory.

Salmonella spp. and Shigella spp. produce febrile and dysenteric syndromes. Nursing tasks include obtaining appropriate specimens (stool in Cary–Blair transport medium or rectal swab), implementing contact precautions for dysenteric illnesses, and monitoring for complications (sepsis, reactive arthritis). Timely specimen handling, cold-chain maintenance, and documentation for public-health trace-back are essential nursing responsibilities.

1.2. Environmental bacteria

Legionella spp. proliferate in warm water systems, form biofilms, and are associated with Legionnaires' disease (severe pneumonia) and Pontiac fever (self-limited febrile illness). Risk factors include hospitalised, elderly, or immunocompromised patients, and exposure may be health-care associated (humidifiers, showers, faucets, cooling towers, devices). Nurses should suspect legionellosis when pneumonia develops after hospital admission or following water aerosol exposure and request Legionella urine antigen testing and respiratory cultures on BCYE agar. Nursing interventions include enforcing source-control measures (removal/avoidance of implicated devices), cohorting affected patients, and coordinating with facilities management for water system testing and remediation. Empiric treatment typically involves a macrolide or fluoroquinolone; ensure antimicrobial stewardship aligns with local protocols.

Pseudomonas aeruginosa is an opportunistic organism associated with wound infections, catheter-related bloodstream infections, and ventilator-associated pneumonia. It readily colonises sinks, drains, and moist environments and forms recalcitrant biofilms. Nurses should implement strict device care bundles (aseptic technique for line insertion and maintenance, scheduled dressing changes, sink use avoidance near sterile fields), practise contact precautions when indicated, and support environmental cleaning and engineering controls to reduce reservoir colonisation.

1.3. Viral pathogens

Norovirus is highly infectious, with a low infectious dose and environmental stability. Outbreaks in closed settings (hospitals, long-term care) require rapid cohorting, strict contact precautions, and environmental disinfection with chlorine-based agents (alcohol-based sanitizers are less effective against norovirus for hand decontamination; soap and water are preferred after caring for vomiting patients). Nurses triage based on symptom onset and ensure vomiting and diarrhoea are contained to minimise aerosolised spread.

Hepatitis A and E are enterically transmitted viral hepatitides; hepatitis E poses elevated mortality risk in pregnant women. Nursing roles include recognising jaundice and signs of liver failure, arranging serologic testing, advising on post-exposure prophylaxis (immune globulin or HepA vaccine), and educating communities regarding sanitation and vaccination where available.

Enteroviruses and adenoviruses may cause systemic disease; detection in water underscores the need for comprehensive hygiene and surveillance measures. Nurses should consider viral panels in undifferentiated febrile or neurologic illness with suspected water exposure.

1.4. Protozoa

Giardia duodenalis and Cryptosporidium spp. are chlorine-resistant protozoan pathogens that can cause protracted diarrhoea and malabsorption. Cryptosporidium, in particular, has been implicated in large waterborne outbreaks and poses high risk to immunocompromised patients (chronic, life-threatening infection). Nursing care includes ensuring accurate diagnostic testing (stool ova and parasite microscopy, antigen tests, or PCR), counselling on safe water alternatives (boiling, filtration with 1-micron filters), maintaining hydration, and coordinating antiparasitic therapy (metronidazole for Giardia; nitazoxanide for cryptosporidiosis in immunocompetent hosts). Schistosoma spp. exposure should be considered in endemic areas; nurses should recognise acute Katayama fever and chronic sequelae (hepatosplenic disease, urinary tract pathology) and facilitate praziquantel treatment and community education on freshwater exposure avoidance.

1.5. Chemical hazards

Nitrate contamination from agricultural runoff can precipitate infant methemoglobinemia ("blue baby syndrome"); nurses should recognise central cyanosis with low pulse oximetry readings that do not correct with oxygen and arrange for blood methemoglobin levels and prompt methylene blue therapy when indicated. Lead and other heavy metals produce chronic neurodevelopmental impairment and multisystem toxicity; nursing interventions include screening high-risk children, coordinating chelation therapy referrals, and educating families about lead avoidance. Cyanobacterial blooms produce microcystins (hepatotoxins) and neurotoxins; nurses should advise against ingestion and recreational exposure, ensure alternative water supplies, and report events to public health.

1.6. Physical hazards

Physical factors—aging infrastructure, intermittent supply, pressure fluctuations, and cross-connections—facilitate ingress of contaminants and mobilise biofilms that intermittently shed pathogens. Nurses must recognise that clinical clusters following service interruptions may reflect distribution-system breaches and should document timing of symptoms relative to water system events. Collaborating with infection control and environmental health teams to interpret surveillance data, order targeted environmental sampling, and implement immediate risk-reduction actions (boil-water advisories, point-of-use filtration, temporary water supply) is central to nursing public-health practice.

1.7. Implications for nursing

Nurses are at the nexus of clinical management, infection prevention, and public health response for waterborne hazards. Clinically, they must rapidly differentiate syndromes (e.g., cholera-like profuse watery diarrhoea, hospital-onset pneumonia suspicious for Legionella, cluster gastroenteritis suggesting norovirus), prioritise specimen collection (stool in appropriate media, blood cultures before antibiotics, sputum/bronchoalveolar specimens for Legionella, rectal swabs when stool unavailable), and initiate evidence-based therapy and IPC measures. Practical nursing interventions include prompt rehydration (WHO/UNICEF ORS protocols and IV resuscitation guidelines), meticulous I/O and weight monitoring, early warning sign escalation (e.g., oliguria, hypotension, rising creatinine, altered consciousness), contact and droplet precautions as indicated, environmental cleaning oversight, patient and caregiver education on safe water practices (boiling, chlorination, filtration), and timely notification to infection control and public health authorities to trigger source investigation and community-level interventions. Nurses also ensure chain-of-custody for specimens, support antimicrobial stewardship by awaiting diagnostics when safe to do so, and document exposures to inform surveillance and outbreak control. Their interdisciplinary coordination with microbiology, facilities/WASH engineers, and public-health teams is critical to both immediate patient care and broader prevention of waterborne disease.

2. 2. CLINICAL RISK ASSESSMENT STRATEGIES

2.1. Exposure-history

An effective exposure history addresses drinking water source and treatment, recent travel, food exposures, contact with symptomatic individuals, recreational water exposures, occupation-related exposures, and household vulnerabilities (pregnancy, infants, elderly, immunocompromised). In practice this requires structured, time-bound questioning (e.g., onset within the last 14 days) and documentation of specific behaviours that increase risk (consumption of raw or undercooked seafood, ingestion of untreated surface water, recent ingestion of bottled water from reusable containers, or use of point-of-use (POU) filters incorrectly). The use of a standardized checklist embedded in electronic health records (EHRs) or paper intake forms helps ensure completeness (CDC, 2017) and facilitates downstream surveillance and public health reporting. Nursing-specific activities include administering the checklist, clarifying responses with both patient and family members, flagging high-risk answers for immediate clinical review, and entering exposure metadata into the EHR using discrete fields (source, duration, travel destinations, dates of plumbing work or floods). Professionally, nurses should consider cognitive and language barriers when obtaining histories, using interpreter services and teach-back to confirm understanding, and should document uncertainties as part of the clinical record to guide follow-up environmental assessment.

2.2. Key assessment domains

- Clinical presentation and severity: A detailed nursing assessment quantifies stool frequency, character (watery, bloody, mucoid), and associated vomiting, and integrates objective measures—heart rate, blood pressure, capillary refill, urine output, mucous membrane moisture, and orthostatic changes—to grade dehydration. Recognition of red flags (altered mental status, hypotension, tachypnea, jaundice, neurologic deficits) triggers emergent escalation. Clinical evidence supports use of standardized dehydration scoring (WHO/IMCI or other validated pediatric/adult tools) to predict need for IV fluids and hospitalization.
- Epidemiologic context: Nurses should determine whether the presentation is an isolated case versus a cluster by querying household contacts, coworkers, or facility cohorts. An apparent cluster, or local advisories such as boil-water notices or boil-water advisory lift, should prompt immediate infection control measures and discussion with public health. Documentation of temporal clustering in the EHR enables automated alerts when multiple similar entries are recorded.
- Host factors: Assessment should systematically capture age, pregnancy, comorbidities (HIV, diabetes, chronic liver disease), use of immunosuppressants, and presence of devices (nephrostomy tubes, urinary catheters) that predispose to atypical waterborne organisms. Nurses should highlight recent hospitalization, dialysis, or long-term care residence, as these increase the probability of nosocomial water-associated pathogens (e.g., non-tuberculous mycobacteria, Legionella).
- Environmental exposures: Nursing assessment should record the exact potable water source (municipal treated, well, stored/treated onsite), any POU treatments (chlorination tablets, UV units, ceramic filters), recent plumbing repairs, and household WASH (water, sanitation, hygiene) observations: presence of latrines, animal contact, and handwashing facilities. When home visits are part of care, nurses can photograph or note visible plumbing issues for engineering teams.

2.3. Risk stratification

Risk stratification integrates clinical severity, epidemiology, and host vulnerability into low, moderate, and high-risk categories. Low risk: mild, self-limited diarrhoea without fever or comorbidities and safe water source—manage with home oral rehydration therapy (ORT), hygiene counseling, and outpatient follow-up. Moderate risk: frequent vomiting, moderate dehydration, significant comorbidity, or recent travel—consider urgent oral rehydration under supervision, antiemetics, stool testing, and short observation. High risk: severe dehydration, hemodynamic instability, altered mental status, signs of sepsis, pregnancy, infants <6 months, or clustered cases suggestive of outbreak—immediate IV resuscitation, broad diagnostic testing (blood cultures, stool multiplex PCR), hospital admission, and prompt notification of public health. Nurses operationalize stratification by applying validated triage tools, initiating fluid algorithms, and triggering standing orders for diagnostics and empiric therapy when protocols permit.

2.4. Diagnostic strategies

Diagnostic strategies should be pathogen-directed and time-sensitive. For patients with systemic features or severe disease, obtain blood cultures and complete blood count, electrolytes, and lactate. Stool diagnostics include routine microscopy (ova and parasites) when parasitic infection suspected, stool culture for bacterial pathogens, antigen tests for Giardia/Cryptosporidium, and multiplex nucleic acid amplification tests (NAATs) that have higher sensitivity and faster turnaround for common enteric viruses, bacteria, and parasites. Consider repeat specimens if initial tests are negative but clinical suspicion remains high; note that some pathogens (e.g., Vibrio cholerae, Cryptosporidium) may require specific transport media or concentration techniques. Nurses are essential in correct specimen collection—ensuring sufficient stool volume, proper containers, timely transport, appropriate labeling, and use of PPE to prevent contamination. They also counsel patients on withholding antibiotics prior to stool culture where clinically safe, as antibiotics may reduce yield.

2.5. Point-of-care

POC tests for dehydration (urine specific gravity), rapid antigen tests (norovirus; some enteric panels), and portable turbidity or residual chlorine testing can support immediate decisions when available. Urine specific gravity and capillary refill correlate with volume status but can be confounded by diuretics or renal disease; thus nurses should interpret results within the clinical context. Portable residual chlorine meters (free chlorine >0.2–0.5 mg/L generally indicates effective disinfection in distribution systems) and turbidity meters (target <1 NTU for many treatment standards) inform immediate public health advice. Nurses should be trained in the limitations and interpretation of POC results, routine calibration of devices, quality control, and documentation of POC values in the EHR.

2.6. Clinical algorithms

Integrating decision-support tools into EHRs or as laminated clinical pathways supports consistent triage and management. For example, syndromic algorithms for acute watery diarrhoea that prompt rehydration protocols, stool testing orders, and public health notification in defined circumstances streamline nursing actions. Algorithms should include explicit nursing steps—when to initiate ORT versus IV fluids, criteria for isolation, PPE requirements, specimen collection checklists, and escalation triggers. Embedding automated order sets (oral rehydration solution, antiemetic, zinc for young children where indicated) can reduce delays and improve adherence to evidence-based care.

2.7. Communication and escalation

Nurses must be trained to notify infection prevention teams, clinical microbiology, public health authorities, and facility engineering when waterborne pathogens are suspected or environmental hazards identified (WHO, 2016). Clear handoff communication templates (situation-background-assessment-recommendation) ensure critical information—timing of symptom onset, exposure history, POC measurements, and specimen results—is transmitted. Early multidisciplinary communication accelerates outbreak containment and ensures coordinated environmental investigations; nurses often serve as the operational hub, organizing sample collection from environmental sites (faucets, storage tanks), coordinating with laboratories for expedited testing, and educating patients and families on interim water safety measures (boil advisories, bottled water use, point-of-use disinfection) while investigations proceed.

3. INFECTION PREVENTION AND CONTROL (IPC) IN HEALTHCARE SETTINGS

3.1. Core IPC

WASH integration in healthcare requires a systems approach, combining administrative controls, engineering solutions, and point-of-care practices. Operationally this means ensuring reliable supplies of potable water, functioning sanitation infrastructure, continuous availability of soap and alcohol-based hand rub (ABHR), and structured environmental cleaning programmes with validated disinfectants and documented contact times (WHO & UNICEF, 2019). From a nursing perspective this translates into daily checks of supply points (soap, ABHR dispensers, drinking fountains), escalation of outages through defined channels, and participation in multidisciplinary water safety or WASH committees.

Standard precautions remain foundational. Hand hygiene is the single most effective intervention to interrupt transmission: nurses should perform the WHO 'Five Moments' and ensure ABHR is available at the point of care. When hands are visibly soiled, or after exposure to body fluids, handwashing with potable water and soap is required; nurses must enforce the protocol and model compliance (Pittet, 2001). Practical nursing interventions include routine ABHR dispenser maintenance (checking fill levels, functionality), educating staff and families on appropriate products, and using audit-feedback cycles to improve adherence.

Engineering and environmental controls must be integrated into IPC protocols. Nurses should be conversant with facility engineering measures that reduce risks from waterborne organisms: maintenance of hot-water systems to prevent Legionella colonization, routine disinfection of storage tanks and distribution loops, minimization of low-flow or stagnant branches, and prevention of cross-connections between potable and non-potable systems (Fields et al., 2002). Nurses can support these measures by documenting and reporting unused outlets, coordinating scheduled flushing of infrequently used taps, and ensuring that clinical areas have appropriately designed sinks (deep bowls, overflow prevention) and hands-free fixtures to reduce splash and contamination.

3.2. High-risk clinical

Dialysis units: The clinical consequences of water contamination in dialysis (pyrogenic reactions, bacteremia, and sepsis) demand strict controls. Ultrapure dialysis water is required for haemodialysis and haemodiafiltration; nursing responsibilities include daily visual inspections of the water treatment unit, verifying logs for reverse osmosis (RO) system integrity, and monitoring disinfection cycles and bacterial/endotoxin testing results. Nurses should adhere to aseptic technique during catheter access, use single-use or appropriately disinfected dialysis lines, and ensure that reprocessing staff maintain validated disinfection protocols for dialysis machines and tubing.

Neonatal units: Neonates, especially preterm infants, have immature immune systems and are vulnerable to Pseudomonas and other opportunists. Nurses should avoid use of tap water for procedures where sterility is required: use sterile water for reconstituting formula for very-low-birthweight infants or in outbreaks, employ sterile water for irrigation of lines and wounds, and ensure that humidification systems and breast pump parts are cleaned and disinfected per manufacturer and unit policy. Point-of-use sterile filters and single-use devices can reduce risk in high-dependency areas.

Oncology and immunocompromised services: Patients receiving cytotoxic chemotherapy, biologics, or post-transplant immunosuppression require heightened vigilance. Nurses should ensure point-of-entry or point-of-use filtration (e.g., 0.2 µm filters) in rooms for profoundly neutropenic patients, minimize exposure to decorative water features or hydrotherapy, and rapidly report plumbing faults. Mouth care protocols should specify sterile or appropriately treated water for neutropenic oral care; implementation of chlorhexidine bathing may be indicated in selected populations.

Endoscopy and surgical suites: Water for instrument reprocessing must meet validated standards — e.g., RO-treated water with appropriate ultrafiltration for final rinse or sterile water where indicated. Nurses managing reprocessing need competency in risks of biofilm formation within endoscope channels, adherence to manufacturer reprocessing cycles, and verification of microbial testing of rinse water. Routine quality checks, chemical indicator use, and documentation are nursing responsibilities to ensure patient safety.

3.3. Legionella-specific

Prevention of Legionella should be embedded within a Water Safety Plan (WSP). Key technical controls include maintaining appropriate temperature regimes (hot-water storage typically maintained at ≥60°C with distribution designed to deliver ≥50°C at point-of-use, and cold water maintained below 20°C where feasible), minimizing stagnation through routine flushing schedules, and avoiding dead-legs in distribution systems (Fields et al., 2002; CDC, 2017). Routine risk-based sampling, heterotrophic plate counts, and targeted Legionella testing inform remediation. Nursing roles include recognizing clinical syndromes suggestive of Legionnaires' disease, promptly reporting suspected cases, and participating in outbreak containment measures such as deploying point-of-use 0.2 µm filters in high-risk patient rooms.

3.4. Safe water for direct

For procedures with direct patient exposure (wound irrigation, nebulization, bathing of critically ill patients), use of sterile or validated treated water is essential. Nurses must follow unit policies specifying when sterile water, single-use sterile saline, or filtered water is required, ensure correct labeling and storage of sterile fluids, and prevent contamination of nebulizer reservoirs (prefer single-dose vials and discard after use). Competency-based training and audits of practice reduce inadvertent introduction of untreated tap water into sterile pathways.

3.5. Wastewater

Appropriate handling and disposal of wastewater, effluent from bedside procedures, and contaminated materials reduce secondary environmental exposure. Nursing procedures should incorporate segregation of cytotoxic wastes, containment and labeling of infectious effluents, use of sealed containers for drainage, and coordination with environmental services and engineering for safe neutralization or disposal. In addition, safe handling protocols for sharps, drainage bags, and contaminated linens mitigate occupational exposure.

3.6. Education, auditing

Nurses are pivotal in education, audit, and quality improvement for water-related IPC. Effective programmes include incorporation of WASH competencies into orientation, regular hands-on simulations (e.g., catheter hub care, aseptic preparation), and structured audits with direct observation of hand hygiene, sink hygiene, and water-related device use. Use of checklists, transparent feedback loops, and participation in multidisciplinary incident review and root-cause analyses strengthen systems resilience (WHO, 2016). Nurses should document and report water-related IPC breaches promptly and contribute to development and revision of WSPs based on frontline observations.

4. PATIENT AND COMMUNITY EDUCATION

4.1. Core educational

- Sources of risk: Explain how water becomes contaminated (faecal contamination, infrastructure breaches, runoff after flooding) and the specific local hazards (e.g., private wells, intermittent supply).
- Teach the mechanisms of contamination in clinically relevant detail: faecal contamination commonly occurs through open defecation near water sources, poorly sited latrines, or animal access, introducing enteric bacteria, viruses and protozoa. Infrastructure breaches such as broken pipes, cross-connections with wastewater, or intermittent supply can create negative pressure and ingress of contaminated groundwater. Flooding and surface runoff mobilize faecal material and chemicals into wells, springs and distribution systems, raising both microbial and chemical hazards. Local hazards should be mapped and explained: shallow private wells without sanitary seals are high risk; intermittent municipal supply increases reliance on household storage and consequent recontamination; water points used by livestock and humans have mixed-source contamination. Nurses should be able to explain these pathways to caregivers in plain language and link them to actionable steps.
- Safe water storage: Teach use of narrow-mouth containers, lids, designated safe-draw spouts, regular cleaning of storage containers, and the avoidance of dipping hands or cups.
- Provide specifics: recommend rigid, narrow-neck containers with tight-fitting lids and an integrated spigot or safe-draw spout to avoid hand contact with stored water. Demonstrate container cleaning protocols (wash with soap and water, rinse, then disinfect weekly with a mild bleach solution; allow air-drying). Emphasize designated, marked vessels for drinking and separate vessels for other household uses. Advise against "dipping" cups or hands into storage; instead use a clean ladle or the spigot. Point out vector control: keep containers covered to reduce insect contact and mosquito breeding.
- Household water treatment options: Describe options—boiling, chlorination (e.g., sodium hypochlorite), filtration (ceramic, membrane), solar disinfection (SODIS)—their benefits, limitations, and correct methods.
- Boiling: explain that bringing water to a rolling boil for at least 1 minute at sea level (extend to 3 minutes above ~2,000 m altitude) reliably inactivates bacteria, viruses and protozoan cysts. Note practical limitations—fuel cost, time, and risk of recolonization in storage—and counsel on safe cooling and immediate storage in covered narrow-mouth containers (Clasen & Haller, 2008).
- Chlorination: describe household sodium hypochlorite products and the principle of free chlorine residual. Teach proper dosing principles and the need to allow at least 30 minutes contact time; demonstrate use of commercially available dosing devices and explain testing for free residual chlorine using DPD reagents or colorimetric strips (target residual 0.2–0.5 mg/L after contact time in routine settings; higher emergency targets may apply). Discuss limitations: reduced efficacy against Cryptosporidium, taste and odor concerns, and increased chlorine demand in turbid water—hence the need for prefiltration or settling.
- Filtration: differentiate technologies—ceramic filters and gravity-fed ceramic units effectively remove bacteria and protozoa; hollow-fiber or ultrafiltration membranes can remove viruses depending on pore size. Educate on maintenance: regular cleaning/backwashing, replacement schedules for cartridges/ceramic elements, and avoiding contamination of the clean side during maintenance.
- Solar disinfection (SODIS): explain the method—transparent PET bottles filled with clear water exposed to direct sunlight for ~6 hours (or up to 48 hours under cloudy conditions) and the role of UV-A and thermal effects. Stress preconditions (turbidity <30 NTU; otherwise prefilter through cloth) and limitations (not suitable for turbid or highly contaminated water, slower and less effective against some viruses).
- Clinical evidence: succinctly reference that randomized and field trials demonstrate household water treatment and safe storage reduce diarrhoeal incidence, but effectiveness depends on correct, sustained use and contextual suitability (Clasen & Haller, 2008; Conroy et al., 1996).
- Safe infant feeding: Counsel on appropriate reconstitution of formula with safe water, and where breastfeeding alternatives exist, advise on risks of contaminated water.
- Reinforce that exclusive breastfeeding is the safest option for infants when feasible. For formula-fed infants, instruct that reconstitution should use water made microbiologically safe: ideally water boiled and cooled, or prepared using water at ≥70°C for powdered formula where feasible to reduce risks from organisms such as Cronobacter spp., then cooled quickly and fed immediately. Emphasize hygiene of bottles, nipples and hands; teach cleaning, sterilization methods (boiling or steam sterilizers) and safe storage of expressed breastmilk. Discuss practical trade-offs in resource-limited settings and the increased risk of severe diarrhoeal illness in infants exposed to contaminated feeding water.
- Hygiene promotion: Emphasize handwashing at critical times (after defecation, before food preparation, before feeding

children), safe food handling, and sanitation practices.

- Give technique and timing: recommend handwashing with soap and water for at least 20 seconds at critical moments—after defecation or cleaning a child, before food preparation and feeding, after handling animals. If water is scarce, teach alcohol-based hand rub use where available. Include food-safety instructions: separate raw and cooked foods, reheat leftovers to boiling, cover foods, and avoid feeding young children high-risk street foods during outbreaks.
- Reporting and seeking care: Provide guidance on when to seek healthcare (signs of dehydration, bloody diarrhea, persistent fever) and when to report suspected community outbreaks.
- Define clinical red flags: lethargy or inability to drink, sunken eyes, decreased urine output or no wet diapers, persistent vomiting, blood in stool, high fever or prolonged diarrhea (>48 hours) in infants and vulnerable adults. Teach caregivers basic home rehydration (use of ORS; explain correct homemade ORS only if commercial ORS unavailable—WHO formula preferred) and zinc supplementation for children with diarrhea. Instruct nurses to counsel when immediate facility referral is needed and to report clusters or unusual increases in diarrheal disease, detection of pathogens of public health concern (e.g., cholera), or any evidence of contaminated communal water sources to local public health authorities.

4.2. Behavior-change

- Use motivational interviewing techniques and teach-back to confirm understanding.
- Train nurses to use open-ended questions, reflective listening, and to assess readiness to change. For example: "What are the challenges you face when boiling water every day?" Follow with collaboratively set, incremental goals. Use teach-back: ask the caregiver to demonstrate or explain the treatment and storage process until competence is shown.
- Tailor messages to local practices and perceived barriers (e.g., fuel cost for boiling, taste aversion to chlorinated water).
- Provide alternatives that address specific barriers: promote SODIS or filtration where fuel is limiting; demonstrate ways to reduce chlorine taste (correct dosing, letting treated water stand under cover) and offer low-cost prefiltration options for turbid water. Address gendered roles and financial constraints sensitively; involve household decision-makers in the planning.
- Leverage community structures: partner with community health workers, schools, and religious organizations to disseminate messages and reinforce adoption.
- Develop peer-led demonstrations, school-based hygiene curricula and faith-leader endorsements to normalize practices. Equip community health workers with simple job aids, chlorine test strips, and demonstration kits to increase credibility and reach.

4.3. Education delivery

- Bedside counseling: brief, individualized, and reinforced with printed or pictorial materials.
- Use a structured bedside script: assess current practices, demonstrate priority actions, set one or two achievable goals, and provide pictorial take-home materials that show stepwise procedures.
- Group sessions: interactive demonstrations on household water treatment and container cleaning.
- Include hands-on practice with boiling, dosing chlorine, assembling filters and preparing SODIS bottles. Use competency checklists and peer feedback.
- Mass media and mobile health (mHealth): SMS reminders, radio spots, and social media for broader reach.
- Implement scheduled SMS prompts for daily treatment reminders, water safety tips and outbreak alerts. Use radio spots in local languages and social media for urban populations; combine mass messaging with interpersonal follow-up for higher uptake.
- Demonstrations: demonstration of chlorine titration, filter use and cleaning, and SODIS bottle placement.
- Conduct practical demonstrations using DPD test kits or colorimetric strips to show correct chlorine residual, demonstrate routine maintenance of ceramic and membrane filters (cleaning/backwashing, replacement intervals), and SODIS placement (flat surface, horizontal exposure, marking start/end times).

4.4. Monitoring adoption

Nurses should incorporate follow-up questions during clinic visits to assess adherence, observe storage containers when possible, and document barriers to uptake. - Use standardized follow-up questions ("When did you last treat your water?" "Can you show me your drinking container?") and observational checklists to assess container cleanliness, presence of a tap/spigot, and storage location. When feasible, perform spot residual chlorine testing or rapid E. coli field tests to validate self-report. Community surveys and household spot-checks conducted by nursing teams or community health workers can inform iterative improvement. - Implement simple monitoring metrics: percentage of households with safe storage, proportion demonstrating correct treatment, and common barriers. Feed results back to communities in brief reports and use

Plan-Do-Study-Act cycles to refine interventions. Nurses act as clinical educators, data collectors and advocates—linking families to supplies, coordinating with public health, and escalating outbreak signals promptly.

5. ENVIRONMENTAL HEALTH SURVEILLANCE

5.1. Types of surveillance

- Indicator-based surveillance: Routine monitoring of microbial and physicochemical indicators remains the backbone of operational water safety surveillance. Typical indicators include E. coli (used as a direct faecal contamination indicator; detection thresholds commonly used are any detection per 100 mL as unacceptable for drinking water), total coliforms (useful for detecting treatment or distribution failures), heterotrophic plate counts (HPCs) as a proxy for system hygiene, residual free chlorine (target 0.2–0.5 mg/L at point of delivery in many systems, higher values may be required in emergency contexts), and turbidity (often expressed in NTU; values >1 NTU reduce disinfection efficacy). Nurses engaged in indicator programs should be familiar with sampling points (source, post-treatment, distribution, and point-of-use), diurnal variability, and the interpretation of single positive versus repeated positives that trigger escalation. Understanding analytic limitations (e.g., enteric viruses and protozoa are not detected by routine bacterial indicators) is important for risk communication.
- Syndromic surveillance: Monitoring syndromes at primary care and emergency departments—acute watery diarrhoea, dysentery, vomiting clusters, and febrile jaundice—provides a clinical early-warning system for possible waterborne outbreaks. Standardized case definitions (e.g., ≥3 loose stools in 24 hours for acute diarrhoea) and sentinel site selection (facilities serving vulnerable populations, refugee camps, or institutions) improve sensitivity. Clinical thresholds for action (e.g., twofold increase over baseline weekly diarrhoeal consultations) should be defined locally. Nurse-led triage protocols that capture age, dehydration status, recent water exposures, and household-level water treatment practices increase the utility of syndromic data.
- Event-based surveillance: Rapid detection of abnormal events reported through informal channels—community informants, complaints hotlines, local media, and social media—can identify outbreaks before laboratory confirmation. Event validation uses a risk-assessment matrix considering number affected, severity, population vulnerability, and plausibility of waterborne transmission. Nurses can serve as frontline verifiers, conducting rapid household interviews, spot checks of water supplies, and initiating provisional control measures while awaiting formal investigation.
- Environmental sampling: Targeted environmental sampling is necessary when indicator or syndromic signals suggest a localized source. Methods include grab sampling, composite sampling, membrane filtration for E. coli and coliforms, and specialized assays for Legionella (culture from plumbing systems), Pseudomonas aeruginosa (important in neonatal and dialysis settings), and endotoxin testing for dialysis water. Nurses working in healthcare settings must be aware of high-risk outlets—neonatal incubator taps, haemodialysis water loops, ice machines—and ensure sampling protocols address biofilms, dead-legs, and temperature control. Coordination with engineers for swab sampling of biofilm and with laboratories for appropriate sample volumes and transport is critical.

5.2. Sampling strategy

Effective sampling strategies must balance frequency, representativeness, and laboratory capacity. Risk-based sampling prioritizes vulnerable settings (paediatric wards, maternity, dialysis units) and critical control points (post-treatment, distal taps). Sampling frequency may range from daily in outbreak response to monthly or quarterly for routine monitoring, but must be increased following any positive indicator or clinical signal. Nurses are often responsible for coordinating sample collection, ensuring aseptic technique, correct sample volume, proper preservatives where required, adherence to chain-of-custody documentation, and maintenance of the cold chain (typically 4 ± 2°C) during transport. Use of portable field kits for free chlorine, turbidity, and presence/absence E. coli tests supports rapid decision-making; positive field results should be confirmed by central laboratories using quantitative membrane filtration or Most Probable Number (MPN) techniques. Quality assurance measures—duplicate samples, field blanks, timely laboratory turnaround, and proficiency testing—should be built into protocols, and nurses should document sampling metadata (time, location, recent cleaning, residual disinfectant) to aid interpretation.

5.3. Integration and data

- Linkage of clinical and environmental data enables epidemiologic triangulation. Combining patient addresses, onset dates, and laboratory results with water distribution maps can reveal spatiotemporal clustering; an excess attack rate in one distribution zone concurrent with positive post-treatment samples is strongly suggestive of system-level failure. Analytical methods include time-series analysis, case-control exposure studies, and rapid cohort investigations.
- Geospatial information systems (GIS), interactive dashboards, and automated alert algorithms enhance situational awareness. Dashboards should display time-stamped clinical counts, laboratory confirmations, and environmental indicator results, with auto-notifications when pre-defined thresholds are exceeded. Nursing staff contribution to data completeness and timeliness is crucial; delayed or incomplete reporting undermines analytic sensitivity.

- Surveillance outputs must be operationalized. Clear decision pathways should translate signals into actions: issuing boil-water advisories, distributing point-of-use (POU) chlorination units or filters, prioritizing pipeline repairs, or temporarily diverting vulnerable patients from at-risk water sources (e.g., suspending dialysis or using sterile fluids). Nurses play a central role in implementing these measures and documenting outcomes.

5.4. Role of nursing

- Case identification and reporting: Nurses apply standardized case definitions, conduct structured histories that capture water exposures and household treatment, and escalate suspected outbreaks through predefined channels. They also ensure complete documentation for public health investigation.
- Environmental liaison: Nurses coordinate with environmental health officers, microbiologists, and engineers to facilitate sampling logistics, interpret indicator results in clinical context, and prioritize remedial actions based on patient acuity and facility risk.
- Community-based surveillance: Community health nurses recruit, train, and supervise community volunteers to recognize and report early warning signals, teach basic sampling (e.g., bottle grab sampling where appropriate), and maintain culturally appropriate communication channels to encourage timely reporting.
- Clinical and community interventions: Nursing interventions include rapid assessment and management of dehydration (ORS, zinc for children), appropriate triage and referral, reinforcing hand hygiene and safe water storage at the point of use, and instructing households on correct chlorination, boiling procedures, and maintenance of POU devices. In healthcare settings, nurses ensure water-based medical devices are managed per infection prevention protocols (e.g., sterile water for neonatal baths, regular disinfection of humidifiers).
- Quality assurance and leadership: Nurses contribute to sampling quality assurance, conduct audits of reporting completeness and adherence to testing schedules, lead after-action reviews following events, and advocate for resources to sustain surveillance. Professional competencies in communication, interdisciplinary collaboration, and ethical community engagement are essential to maintain public trust and drive effective outbreak control.

6. HOSPITAL WATER SAFETY PLANS (WSPS)

6.1. Core components

A robust Water Safety Plan (WSP) requires structured components that translate engineering and microbiology principles into practical, auditable controls. Team formation should be multidisciplinary: in addition to nurses and physicians, representation must include infection preventionists, facility/plant engineers, microbiologists or laboratory directors, environmental health specialists, procurement, pharmacy, and senior administrators. Regularly scheduled meetings with clear terms of reference, delegated authorities for immediate actions (e.g., closing a shower room), and escalation pathways are essential.

System assessment is a technical mapping exercise that documents the entire water supply pathway from the municipal inlet or well through storage tanks, treatment units, distribution mains, risers, branch lines, and point-of-use (POU) outlets. Mapping should identify hydraulic features that favor stagnation and biofilm formation (dead-legs, low-flow zones, oversized storage tanks, bypass loops) and incorporate records of pipe materials, ages, insulation, and thermal losses. Tools such as dye testing, acoustic flow metering, and hydraulic modelling can support identification of vulnerable points.

Hazard analysis and risk assessment must consider microbiologic hazards (Legionella spp., non-tuberculous mycobacteria, Pseudomonas aeruginosa), faecal contamination indicators (E. coli), and chemical hazards (disinfection by-products, heavy metals). Risk characterization should evaluate both the likelihood of colonization/contamination and the potential clinical consequences for specific patient populations (e.g., transplant recipients, neonatal intensive care). Quantitative microbial risk assessment (QMRA) approaches can be applied where data permit.

Control measures need to be layered and redundant. Source protection includes preventing ingress of contaminants into the municipal supply and maintaining backflow prevention. Treatment barriers encompass primary disinfection (chlorination, chloramination, ultraviolet) and secondary residual maintenance. Thermal control strategies typically aim to keep hot water storage at ≥60°C and distal hot-water outlet temperatures that minimize scald risk while reducing Legionella growth (many guidance frameworks target ≥50–55°C at outlets after system balancing), noting that thermostatic mixing valves (TMVs) introduce distal cool zones. Flushing regimes—daily to weekly depending on use—reduce stagnation; dead-leg removal and reconfiguration limit biofilm niches. Where necessary, POU interventions such as 0.2 µm sterile filters or validated antimicrobial filters are applied in high-risk areas (oncology, transplant, neonatal units). Engineering interventions may include continuous chloramine dosing, copper-silver ionization, and periodic thermal shock flushing; each requires validation and attention to by-products and corrosion.

Monitoring and verification protocols should specify routine measurement frequencies and methods: residual disinfectant (free chlorine or monochloramine) at sentinel points, hot and cold water temperatures, heterotrophic plate counts (HPC), and targeted pathogen testing (Legionella culture and PCR). Sampling strategies should include first-draw and post-flush samples at sentinel high-risk outlets and upstream samples to localize contamination. Verification includes review of operational logs, filter change records, and efficacy testing after remedial actions (e.g., successful eradication after thermal disinfection). Validation of long-term controls (e.g., continuous chloramination) requires trend analysis and periodic independent laboratory assessment.

Management and communication require documented procedures for routine operation and for incidents. Typical incident actions include immediate closure of affected outlets, provision of bottled or sterile water for drinking and clinical uses, initiation of targeted disinfection, notification of public health authorities, and patient risk stratification. Clear roles, responsibilities, and communication templates (staff alerts, patient advisories, media statements) must be pre-prepared.

Review and improvement should happen at defined intervals and after key events. Reviews incorporate infrastructure changes, HAI surveillance data, technological advances, and regulatory updates. A continuous quality improvement approach with key performance indicators (e.g., percentage of outlets meeting temperature targets, time to repair, absence of Legionella in high-risk outlets) supports accountability.

6.2. Nursing roles

Nurses are central to operationalizing WSPs at the bedside and translating technical controls into patient-centred practice. As clinical representatives on WSP teams, nurses identify care processes that rely on water (e.g., wound irrigation, nebulization, enteral tube flushes, oral care, bathing) and elucidate patient vulnerabilities—neutropenic patients, neonates, or those with indwelling devices—so risks are contextualized and prioritized.

Day-to-day monitoring by nursing staff includes simple but impactful checks: verifying availability of safe drinking water and sterile water supplies at ward level; confirming presence, correct installation, and integrity of POU filters; inspecting taps, showers, and ice machines for visible contamination or biofilm, and recording outlet temperatures where local policy requires. Nursing staff can complete standardized checklists at shift handover that capture observations of water discoloration, taste complaints, or pressure anomalies and trigger engineering or infection prevention referrals.

In incident response, frontline nurses enact immediate patient-safety measures: isolating suspected water-associated infections, stopping use of implicated outlets for clinical procedures, initiating alternative water provision (bottled, boiled, or sterile single-use water depending on guidance), and documenting exposures in the patient record. Nurses also coordinate specimen collection for clinical and environmental testing, ensuring proper aseptic technique to avoid confounding results.

Education and behavior change is a priority nursing function. Nurses lead training on WSP protocols, reinforce safe practices (e.g., no handwashing in sinks used for body fluid disposal, correct use and replacement of POU filters), and coach staff on patient-specific precautions (e.g., restricting showers for immunocompromised patients). They can implement simple engineering controls at the bedside, such as placing splash guards and ensuring no storage of sterile supplies near sinks.

Nursing data are vital to WSP verification and validation. Timely reporting of clusters of wound infections, bloodstream infections involving water-associated organisms, or unusual febrile illness patterns provides epidemiologic signals that complement laboratory-based environmental surveillance. Nurses contribute to audits, participate in multidisciplinary outbreak reviews, and help translate findings into practice changes.

6.3. Operationalization

Operationalizing WSPs requires institutional governance with allocated budgets for engineering interventions, ongoing laboratory testing, filter procurement and replacement, and staff training. Service level agreements should define response times for plumbing repairs and remedial disinfection. Senior nursing leadership at the governance table ensures clinical priorities are integrated, resources are appropriately allocated to wards with vulnerable patients, and staff engagement is sustained through visible support.

Nursing leadership should mandate competency assessments for bedside staff on WSP-related tasks, embed WSP indicators into ward performance dashboards, and run periodic drills (e.g., simulated boil-water advisory) to rehearse communication and operational responses. Integration with infection prevention programs, occupational health, and antimicrobial stewardship enhances system resilience. A proactive, data-driven nursing contribution transforms WSPs from engineering plans into living, patient-focused safety systems.

7. POINT-OF-USE (POU) WATER MANAGEMENT

7.1. Types of POU

- Boiling: Boiling is microbiologically effective against bacteria, protozoa and viruses when water reaches a rolling boil. Guidance from public health agencies (e.g., CDC) recommends boiling for at least 1 minute at sea level and for 3 minutes above 2,000 m elevation to inactivate thermal-tolerant pathogens. Clinical evidence supports dramatic reductions in diarrhoeal disease where boiling is reliably practiced, but the method is resource intensive: it requires fuel, time and safe containers for cooling and storage and produces indoor air pollution that contributes to respiratory morbidity. Importantly, boiling does not remove chemical contaminants (e.g., heavy metals, nitrate) and can concentrate some volatile organics if cooling is uncontrolled.

- Chlorination (liquid sodium hypochlorite, chlorine tablets): Chlorination is broadly effective against bacteria and most viruses and is commonly implemented in decentralized contexts. Technical considerations include contact time and free chlorine residual: WHO/CDC targets generally recommend maintaining a free chlorine residual of 0.2–0.5 mg/L after at least 30 minutes of contact in clear water. Chlorine demand increases with organic load and turbidity, reducing efficacy; it is largely ineffective against Cryptosporidium oocysts. Taste and odor acceptance affects adherence, and correct dosing (accounting for container volume and turbidity) is essential. Clinically, studies and program evaluations (Clasen & Haller, 2008) show reductions in diarrhoeal incidence when chlorine is used and sustained.
- Filtration: Filtration technologies vary by pore size, material, and flow dynamics. Ceramic candle filters and hollow-fiber membrane filters with nominal pore sizes of 0.2–0.4 µm remove bacteria and protozoa effectively; viruses, being smaller, typically pass through unless adsorptive media or combined disinfection is used. Slow sand filters deliver biological treatment via a schmutzdecke and achieve consistent pathogen removal at household or community scale but require proper maturation and periodic desludging. Maintenance practices (backwashing, scrubbing ceramic elements, replacing membranes) are critical: poor maintenance leads to clogging, reduced flow and risk of recontamination. Silver-impregnated ceramics add residual antimicrobial action but require monitoring for silver release.
- Combined methods: Combining technologies—e.g., turbidity reduction by filtration followed by chlorination, or filtration plus solar disinfection—broadens the hazard removal spectrum (viruses, bacteria, protozoa, and some organic matter) and mitigates single-method limitations. Clinical programmatic evidence indicates better sustained risk reduction when appropriate combinations address local hazard profiles.
- Solar disinfection (SODIS): SODIS uses UV-A radiation and thermal inactivation in transparent PET bottles. Under strong sunlight, 6 hours of exposure is typically sufficient; under intermittent/cloudy conditions, exposure extends to 1–2 days. Efficacy declines with turbidity above ~30 NTU and in colder climates; thus prefiltration or settling is often necessary. Conroy et al. (1996) and subsequent field trials demonstrate reductions in diarrhoeal disease in pediatric populations where SODIS uptake is sustained.
- Point-of-use point-of-entry (POE) systems: In healthcare contexts, POE or point-of-use systems installed at critical outlets (e.g., operating theatres, neonatal units) may include sterilizing-grade 0.2 µm membrane filters or validated ultraviolet units. These are engineered devices subject to validation, routine replacement schedules, and documentation to ensure sterile or clinically acceptable water for procedures. They are not substitutes for sterile solutions when those are required, but serve as critical barriers for high-risk applications.

7.2. Selection criteria

- Hazard profile: Selection must be matched to the predominant hazards. For example, in Cryptosporidium-endemic settings, membrane filtration or combination methods are preferred because chlorination alone will not inactivate oocysts. A nurse-led risk assessment of local epidemiology, turbidity and known chemical exposures should inform choice.
- User acceptability and behavior: Sustained uptake depends on sensory acceptability (taste/odor), simplicity of use, and compatibility with cultural practices. Nurses should conduct brief usability assessments and teach-back demonstrations to identify barriers and adapt counseling.
- Scalability and cost: Nurses can advocate for cost-effective, maintainable interventions by presenting life-cycle costing to administrators, including replacement parts, consumables and training costs. Where budgets constrain choices, prioritize methods that reduce clinical risk in vulnerable groups (neonates, immunocompromised patients).
- Maintenance plan: A robust maintenance plan includes written schedules for cleaning and replacement, clear assignment of responsibility (household member or facility staff), spare-part logistics, and waste-handling procedures for disinfectants. Nurses should integrate these plans into patient education, discharge instructions, and facility infection prevention protocols to reduce secondary contamination.

7.3. Monitoring POU

- Adherence monitoring: Nurses employ home visits, structured clinic follow-up, and community health worker networks to observe real-world use. Simple checklists and direct observation (e.g., presence of treated water in safe storage, correct use of dosing devices) are more reliable than self-report. Motivational interviewing techniques improve sustained behavior change.
- Efficacy monitoring: Periodic objective testing should be scheduled. Field-appropriate tests include DPD colorimetric kits or test strips for free chlorine residuals, portable turbidity meters or visual turbidity tubes (target <5 NTU for most disinfection efficacy; <1 NTU preferred for membrane systems), and microbiological methods such as membrane filtration for E. coli or presence/absence kits (e.g., Colilert or simple field kits). H2S tests or thermotolerant coliform tests can be adjuncts but have specificity limitations. Nurses should be trained in sample collection, chain-of-custody

and interpretation.

- Record-keeping: Maintain logs for filter replacements, chlorination doses, residual readings, device failures and user complaints. Integrate records into electronic medical records or community health registers where possible. Continuous documentation supports quality improvement, procurement forecasting and program sustainability.

7.4. Safety and equity

- Ensure equitable access by prioritizing vulnerable populations (e.g., low-income households, rural clinics, maternal–child wards) and by advocating for subsidized supplies, community distribution schemes, and training that is culturally and linguistically appropriate. Gender-sensitive programming acknowledges that women and girls disproportionately bear water collection and treatment responsibilities.
- POU is an interim and complementary measure. Nurses and clinical leaders should explicitly position POU within a broader water safety plan and advocate for long-term investments in centralized, regulated municipal supplies, infrastructure repair, and regulatory oversight. Emphasize that sustainable public health protection requires structural solutions alongside household-level measures.

8. OUTBREAK INVESTIGATION AND NURSING ROLES

8.1. Early detection

Nurses are often the first clinicians to encounter patients during the early phase of a water- or foodborne outbreak; therefore systematic case-finding is a core nursing function. Implementing standardized case definitions (suspected, probable, confirmed) and using them consistently at triage, inpatient units, and community clinics improves sensitivity and specificity of detection. Active surveillance strategies include syndromic surveillance (monitoring for clusters of acute watery diarrhoea, vomiting, febrile gastroenteritis) and sentinel-site reporting. Triage algorithms should incorporate red flags (hemodynamic instability, high fever, severe abdominal pain, bloody diarrhoea) and automated alerts in electronic health records to flag temporal or spatial clusters. Clinical evidence shows that early identification and cohorting of cases reduces secondary transmission and shortens outbreak duration; therefore nurses should be trained to escalate suspected clusters promptly to infection prevention and public health authorities and initiate outbreak protocols without delay.

8.2. Specimen collection

Nurses supervise and perform specimen collection according to local diagnostic algorithms and laboratory requirements. For enteric pathogens, stool specimens should ideally be collected before antimicrobial therapy, within the first 48–72 hours of symptom onset when possible, and transported under appropriate temperature control. For suspected cholera or bacterial enteritis, bulk stool or rectal swab specimens for culture and PCR are indicated; for viral aetiologies (e.g., norovirus), stool PCR is the gold standard. Respiratory specimens (e.g., nasopharyngeal swabs) are required when respiratory symptoms co-occur. Blood cultures are necessary for febrile systemic illness prior to administration of antibiotics. Nurses ensure proper labeling with patient identifiers, specimen type, date/time of collection, and chain-of-custody documentation where required. They adhere to transport logistics (cold chain, media, timely courier protocols) to preserve specimen integrity. Detailed exposure histories — recent travel, ingestion of high-risk foods, municipal water use, recreational water exposures, childcare or food-service employment, and household contacts — are systematically documented to support epidemiologic linkage and hypothesis generation.

8.3. IPC and patient

Infection prevention and control (IPC) measures tailored to the pathogen are nursing-led at the bedside and in communal settings. Symptomatic patients should be placed in single rooms when available or cohorted with patients sharing the same pathogen and symptom onset. Cohorting principles include grouping by pathogen and restricting staff assignments to minimize cross-coverage. Personal protective equipment (PPE) use follows transmission-based precautions; for vomiting or uncontrolled diarrhoea, gowns and gloves are essential, and masks/eye protection may be indicated for aerosol-generating events. For norovirus, hand-washing with soap and water is emphasized because alcohol-based sanitizers have reduced efficacy; environmental cleaning requires chlorine-based disinfectants at recommended concentrations (e.g., 1,000–5,000 ppm available chlorine) with specified contact times. Nursing responsibilities include meticulous waste handling, linen management, and monitoring adherence to hand hygiene protocols. Clinically, nurses deliver supportive care: initiate oral rehydration therapy (use WHO-recommended ORS formulations), titrate intravenous fluids for severe dehydration or shock, monitor fluid responsiveness and electrolytes, and implement antiemetic strategies to facilitate rehydration. Empiric antibiotic therapy should be given only per clinical protocols and microbiologic guidance (e.g., severe cholera or suspected invasive bacterial infection); nurses ensure baseline specimens are collected before antibiotics and monitor for adverse effects.

8.4. Environmental investigation

Nurses serve as liaisons between clinical teams and environmental health officers during environmental investigations. They provide detailed case data used to generate exposure maps and epidemic curves (dates of onset, spatial clustering, common venues), and identify vulnerable subpopulations (infants, elderly, immunocompromised) based on clinical severity patterns. Nurses assist in coordinating water sampling logistics (collection points, sample timing relative to outbreak timeline), noting on-site observations such as turbidity, chlorination residuals, and maintenance issues. Their bedside observations (e.g., disproportionate illness among daycare attendees or patrons of a particular food outlet) often guide targeted environmental sampling and hypothesis testing, accelerating source identification.

8.5. Risk communication

Nurses contribute substantively to risk communication efforts, translating technical findings into clear, actionable messages about boil-water advisories, safe food handling, home isolation, and when to seek medical care. They apply principles of health literacy and cultural competence—providing translated materials, using teach-back techniques, and engaging community leaders—to increase adherence to public health advice. Because nurses are generally trusted health professionals, their messaging improves community compliance; they also monitor and correct misinformation via social media and local outreach, and they coordinate with public health communications to ensure consistency and timeliness of messages.

8.6. Analytic epidemiology

Nurses support analytic epidemiologic investigations by contributing to case ascertainment, designing and administering standardized questionnaires, and conducting follow-up interviews. Their meticulous documentation of clinical variables (symptom onset, severity, comorbidities, outcomes) enhances data quality and reduces misclassification. In field studies (cohort or case-control), nurses assist with sampling frames, recruiting participants, collecting exposure and outcome data, and ensuring informed consent and confidentiality. High-quality patient-level data collected by nurses facilitate valid calculations of attack rates, relative risks, and odds ratios that underpin control recommendations.

8.7. Post-outbreak

After outbreak control, nurses participate in after-action reviews and quality improvement activities. They document timelines, IPC lapses, laboratory findings, and patient outcomes, and translate lessons learned into revised water safety plans, updated clinical and triage protocols, and targeted staff retraining. Nurses may lead simulation exercises, revision of standard operating procedures, and community education initiatives (including vaccination campaigns where applicable) to prevent recurrence. Additionally, they address staff wellbeing, provide debriefing, and contribute to reports required for accreditation and public health records, ensuring operational resilience for future events.

9. DISASTER RESPONSE AND EMERGENCY WASH

9.1. Rapid needs

Nurses engaged in initial rapid assessments perform structured, clinically oriented WASH (Water, Sanitation, and Hygiene) needs assessments that integrate epidemiologic risk appraisal with bedside triage priorities. Using checklists adapted from Sphere, WHO and local public health guidance, nurses document water quantity (liters per person per day), access points, visible contamination, turbidity measurements, and water source protection. Practical measurements commonly employed by nurses include on-site turbidity checks (target <5 NTU for effective chlorination), and simple free residual chlorine testing using DPD colorimetric test kits to ensure maintenance of residual disinfectant at recommended emergency minima. Sanitation assessments evaluate latrine functionality, gender-segregation, menstrual hygiene management needs, and fecal sludge management to reduce environmental contamination. Crowding metrics—persons per square meter in shelters, sleeping density, and the proportion of high-risk individuals (infants, pregnant women, elderly, immunocompromised, those on dialysis or receiving enteral feeding)—are recorded because these increase transmission risk of diarrheal and respiratory pathogens. Rapid assessments also capture health-care capacity (neonatal units, dialysis, operating theatres) and supply gaps to inform immediate prioritization.

9.2. Provision of safe

Short-term safe water strategies are multimodal and nurse-facilitated. Common interventions include distribution of chlorinated water from bulk tanks or tankers with verified treatment, provision of household point-of-use (POU) kits (sodium hypochlorite solution, chlorine tablets, ceramic or ultrafiltration devices), and distribution of safe storage containers (narrow-neck jerrycans with taps) to limit recontamination. Nurses implement recipient prioritization frameworks based on clinical need and resource scarcity: first-line allocation to healthcare facilities, neonatal and paediatric units, dialysis services and haemodialysis water treatment plants, operating rooms, and individuals with compromised immunity or chronic fluid-sensitive therapies. Clinical evidence supports these priorities: outbreaks and increased morbidity occur when critical care units lack potable water for medication preparation, wound cleansing, or dialysis water pre-treatment. Nursing-specific interventions include bedside water quality checks prior to administration of IV fluids or enteral feeds, training family caregivers in POU chlorination techniques, and documenting water sources used for medication and feeding preparation to prevent iatrogenic infection.

9.3. Infection prevention in temporary

Temporary facilities—field hospitals and shelters—require operationalized infection prevention and control (IPC) protocols adapted for low-resource, high-turnover settings. Nurses lead development and enforcement of hand hygiene stations (soap and water where hands visibly soiled; alcohol-based hand rubs with 60–80% alcohol for routine use), establish color-coded waste segregation and sharps disposal, and implement environmental cleaning regimens with appropriate disinfectant concentrations (e.g., chlorine solutions ~0.05% for general surfaces, 0.5% for body fluid spills as per WHO guidance). Safe water handling protocols include verification of free chlorine residuals, designated water-handling pathways for clinical and non-clinical use, and strict rules for storage and decanting to prevent cross-contamination. Nurses operationalize IPC by creating competency checklists, conducting daily briefings, supervising cleaning teams, and instituting occupational health measures (PPE, vaccination, exposure reporting). Clinical evidence demonstrates that consistent hand hygiene and environmental cleaning reduce healthcare-associated infections in temporary settings; nurses' teaching and audit roles are therefore crucial. Ensuring uninterrupted supply chains for soap, hand rub, disinfectant, and PPE is part of nursing logistics coordination.

9.4. Cholera

In cholera responses, nurses have central clinical and public health responsibilities. Within cholera treatment centers they implement rapid triage using dehydration status (none, some, severe), initiate oral rehydration therapy (ORS) for mild-moderate dehydration and intravenous rehydration (typically Ringer's lactate or isotonic crystalloids) for severe cases, monitor urine output, vital signs, and serum electrolytes, and manage ongoing losses. Nursing-led rehydration protocols and standardized charts for fluid replacement shorten time to rehydration and reduce mortality; monitoring for complications such as hypokalemia is routine. IPC measures in cholera wards include cohorting, dedicated sluice and sanitation facilities, and strict waste disposal. During oral cholera vaccine (OCV) campaigns nurses are involved in cold-chain management (maintaining 2–8°C, use of vaccine vial monitors), administration, documentation of doses, and active surveillance for adverse events following immunization (AEFI). Nurses also provide community education on household water treatment, safe food handling, and signs that indicate need for urgent care — all interventions supported by outbreak control evidence.

9.5. Coordination and logistics

Nurses participate actively in interagency coordination mechanisms (Health/WASH cluster meetings), translating clinical needs into actionable logistics requests for water treatment capacity, engineering repairs, and community mobilization. They maintain clinical supply inventories, forecast needs (IV fluids, ORS, dialysis consumables, disinfectants), and manage vaccine and medication cold chains. Nursing responsibilities include systematic documentation of interventions, case-based surveillance, and data collection using standard tools (facility registers, EWARS, mobile data collection platforms). Timely reporting of waterborne disease patterns and healthcare-acquired infection trends informs public health responses and resource allocation. Professional insight: embedding nurses within coordination structures improves alignment between clinical realities and engineered WASH solutions, ensuring interventions are both medically necessary and operationally feasible.

9.6. Psychosocial

Nurses address psychosocial stressors through Psychological First Aid, screening for anxiety, depression and PTSD using brief validated tools (e.g., PHQ-2/9, GAD-2/7) and activating referral pathways for mental health services. They ensure continuity of care for chronic conditions—maintaining renal replacement therapy schedules, antenatal care, insulin supply with cold-chain where needed, and access to clean water for medication administration and wound care. Nursing interventions include medication reconciliation, development of individualized care plans that account for limited water access (e.g., waterless skin care protocols), and liaison with social services to secure shelter and safe sanitation for vulnerable patients. Clinically, preserving continuity mitigates morbidity and prevents secondary surges in mortality post-disaster.

10. QUALITY IMPROVEMENT AND DASHBOARDS

10.1. Key performance

Key performance indicators (KPIs) should be specific, measurable, time-bound and linked to patient safety outcomes. For water safety these include structural/process/outcome measures such as: - Proportion of wards with accessible, safe drinking water at all times. Define "accessible" (within X metres/at bedside availability for high-dependency patients) and "safe" (meets defined residual disinfectant and microbiological thresholds). Targets should be explicit (e.g., 100% critical care coverage; ≥95% general wards). - Compliance with hand hygiene and availability of alcohol-based hand rub and soap. Link the presence and functioning of hand hygiene stations to water-supply reliability — sinks may be unusable during outages and alternative measures must be in place. Track percentage of hand hygiene stations stocked and functional by shift. - Time from report of water system failure to implementation of mitigation (e.g., provision of bottled water, point-of-use filters, temporary hand-rub dispensers). Mitigation-response targets should be tiered by risk area (example: ICU within 1 hour, maternity/NICU within 2 hours, routine wards within 4 hours), documented in escalation protocols and audited. - Rate of healthcare-associated waterborne infections (e.g., Pseudomonas aeruginosa bloodstream infections, Legionella-associated pneumonia). Use surveillance definitions, attribute probable vs. definite water source where possible, and calculate incidence per 1,000 patient-days or device-days. Trend analysis can reveal clusters linked to plumbing fixtures or practices (e.g., use of tap water for enteral feeding). - Adherence to scheduled Water Safety Plan (WSP) monitoring (temperature logs, residual chlorine checks, heterotrophic plate counts, Legionella sampling). Specify monitoring frequency (e.g., temperature and residual chlorine daily in critical care, weekly in general wards; microbiological sampling monthly/quarterly based on risk assessment) and acceptable ranges. Include audit of documentation completeness and corrective action timeliness.

Clinical evidence supports that rigorous monitoring and rapid mitigation reduce outbreaks: several hospital NICU outbreaks of Pseudomonas and other Gram-negative organisms have been traced to contaminated sinks, tap aerators, or water used for reconstitution of feeds. Legionella outbreaks in healthcare settings are associated with inadequate thermal control and lapses in disinfectant residuals; maintaining appropriate hot-water temperatures and residual disinfectant reduces colonization risk.

Nursing-specific responsibilities should be explicit in KPI frameworks: daily point-of-care checks, documentation of outlet functionality, flagging anomalous temperatures or tastes/odours, and ensuring alternative safe water provision when outages occur. Incorporate competency assessments for nurses on WSP procedures and safe water practices for vulnerable populations (neonates, immunocompromised patients).

10.2. Dashboards

Dashboards translate KPIs into actionable intelligence. Effective dashboards: - Consolidate KPIs with clear visual cues (traffic-light color coding), enabling rapid identification of problems by shift or location. Thresholds that trigger colors should be evidence-based and locally agreed (e.g., residual chlorine <0.2 mg/L = amber; no residual = red). - Provide drill-down capability from hospital-level metrics to ward and outlet level, allowing nursing unit managers to identify the specific sink or dispenser requiring action. - Integrate automated alerts (SMS/email/push notifications) when thresholds are breached or when scheduled monitoring is overdue; feed into the clinical escalation pathway. - Link to maintenance and asset-management systems so that plumbing work orders, filter change schedules, and sample-history are visible. Embedding QR codes at sinks that open the outlet page with last test date, responsible person, and instructions supports point-of-care decision-making. - Provide mobile access for bedside nurses and infection control teams. Dashboards should display run-charts and statistical process control (SPC) charts to detect trends and early signals of deterioration.

Nursing units can maintain ward-level dashboards that feed into hospital-wide displays. This fosters local ownership and enables targeted interventions (e.g., focused sink decontamination rounds, replacement of aerators in a specific bay).

10.3. QI cycles

Continuous quality improvement provides the operational methodology to close gaps: - Use Plan–Do–Study–Act (PDSA) cycles to test small changes rapidly. For example, Plan: introduce single-use sterile water for bedside enteral medication preparation in one ward; Do: implement for 2 weeks with nurse champions; Study: measure contamination rates of feeds and compliance; Act: scale or modify based on results. - Perform root cause analyses (RCA) and Failure Mode and Effects Analysis (FMEA) for incidents such as a Pseudomonas bloodstream cluster or a prolonged water outage. Document latent system failures (e.g., lack of spare pumps, unclear escalation pathways) and assign remediation owners. - Use audits, direct observation, and data visualization (run-charts, SPC charts) to determine whether changes produce sustained improvement. Define balancing measures (e.g., cost, staff workload) and safety checks. - Nurses are pivotal in leading PDSAs focusing on bedside issues: improving availability of safe drinking water at the bedside, reducing contamination during bottle-feeding and medication reconstitution (introduce checklists and clean-field techniques), standardizing reporting of plumbing issues through a simple bedside form that triggers the clinical engineering response. - Engage nurse champions and infection prevention liaisons for ongoing education, competency validation, and peer-led audits. Link improvements to mandatory in-service modules and simulation exercises for water-outage scenarios.

10.4. Feedback

Timely, constructive feedback sustains engagement and improves adherence: - Provide regular feedback of performance data to frontline staff via shift huddles, unit meetings, e-mail summaries, and real-time dashboard displays. Include contextual narrative — not just numbers — describing what actions were taken and why. - Recognize and reward units that achieve or exceed targets; visible recognition (e.g., “Water Safety Unit of the Month”) and small incentives reinforce desired behaviours. - Conduct interprofessional review meetings that include nursing representatives, infection prevention, facilities/engineering, microbiology, and hospital leadership. Nursing perspectives are essential to align clinical priorities (e.g., patient hydration, enteral feeding safety) with engineering responses (e.g., temporary supply routes, installation of point-of-use filters). - Use debriefs after incidents to share lessons learned, update protocols, and simulate revised workflows. Encourage psychological safety so staff report near-misses and barriers without fear of punitive action. - Embed WSP performance and feedback into nursing orientation and ongoing professional development so that water safety becomes part of routine clinical vigilance and quality culture.

11. STAFF COMPETENCY AND TRAINING

11.1. Core competency

- Knowledge: Nurses must possess an in-depth, evidence-informed understanding of the epidemiology of waterborne diseases including typical pathogens (e.g., enteric viruses such as norovirus and rotavirus, bacterial agents such as Salmonella, Shigella, Vibrio spp., Legionella, and protozoa such as Giardia and Cryptosporidium), modes of transmission (fecal–oral, aerosolization, biofilm-associated dissemination), incubation periods, and high-risk populations (neonates, elderly, immunocompromised). They should understand basic water treatment principles—coagulation, sedimentation, filtration, disinfection (chlorination, monochloramine), and advanced methods (UV, ozonation, membrane filtration)—and how treatment failures manifest clinically. Competency includes hazard recognition (biofilm hotspots, dead legs in plumbing, poorly designed sinks or splash-prone handwashing areas, contaminated point-of-use (POU) devices), and familiarity with institutional Water Safety Plan (WSP) components: system description, hazard analysis, operational monitoring, corrective actions, verification and documentation.
- Clinical skills: Practical clinical skills include structured exposure-history taking that elicits recent travel, dietary and recreational water exposures, use of home or POU treatment devices, recent hospital exposures, and device use (e.g., humidifiers, showering in healthcare settings). Nurses should be competent in specimen collection (stool sample technique, timing relative to symptom onset, rectal swabs for infants, sputum or bronchoalveolar lavage for suspected Legionella with appropriate transport media and chain-of-custody) and understand laboratory priorities. Proficiency in dehydration assessment (skin turgor, mucous membranes, capillary refill, respiratory pattern, urine output, orthostatic changes) and evidence-based management—WHO/UNICEF ORS for most cases, age/weight-based IV fluid dosing for severe dehydration, electrolyte correction, and monitoring for refeeding or rehydration syndrome—must be demonstrated.
- IPC competencies: Infection prevention competencies should include the "five moments" of hand hygiene applied to waterborne risks, understanding when soap and water are preferred over alcohol-based rubs (e.g., after exposure to Clostridioides difficile-like diarrheal stools or visibly soiled hands), and rigorous device care to avoid water contamination (use of sterile/filtered water for rinsing respiratory equipment, avoidance of tap water for wound care or mouth care in high-risk patients). Nurses should be able to implement outbreak containment procedures: patient cohorting, restriction of specific water fixtures, placement of POU filters or bottled water, enhanced environmental cleaning, and initiation of institutional WSP corrective actions.
- Environmental liaison: Nurses acting as clinical-environmental liaisons should be trained in basic environmental sampling procedures (which samples to request—bulk water, first-draw vs. flushed samples, swabs for biofilm—approximate volumes, aseptic technique, labeling, and required holding temperatures). They must understand reporting pathways (infection prevention, microbiology, facilities engineering, public health authorities) and be conversant about engineering controls used to mitigate risk (thermal control strategies for Legionella, point-of-entry and point-of-use filtration, backflow prevention, dead-leg elimination, and continuous disinfectant residual management).
- Communication: Effective risk communication skills include delivering clear, actionable instructions to patients and families (e.g., boiling recommendations, ORS preparation), using teach-back to confirm understanding, creating culturally and linguistically appropriate educational materials, and engaging community stakeholders. Nurses should be prepared to coordinate public messaging during incidents, balancing transparency with avoidance of unnecessary alarm.

11.2. Training modalities

- Didactic sessions: Integrate water-safety content into undergraduate and continuing professional development curricula with modules on microbial ecology of water systems, WSP frameworks, and clinical case studies. Include assessment via written exams and case-based discussions to ensure knowledge transfer.
- Simulation: Build realistic, scenario-based simulations (tabletop and full-scale) for outbreak triage, activation of WSP protocols, POU distribution and installation, and patient management (severe dehydration, suspected Legionella pneumonia). Use high-fidelity mannequins and standardized patients to evaluate clinical decision-making, communication, and leadership; record and debrief performance against objective metrics.
- On-the-job mentorship: Implement structured preceptorships pairing nurses with infection preventionists, public health officers, and environmental health engineers. Use competency checklists, reflective practice journals, and case reviews to reinforce experiential learning and rapid problem solving during real incidents.
- E-learning modules: Develop scalable online modules with interactive elements (video demonstrations of water sampling and POU filter installation), formative assessments, scenario branching, and completion badges. Maintain version control so content reflects current guidelines and local infrastructure differences.

11.3. Assessment

- Competency validation: Employ multi-modal assessment—checklists for procedural tasks (stool collection, POU filter installation), direct observation with real-time feedback, and OSCE stations focused on exposure history, dehydration management, IPC application, and environmental liaison communication. Objective criteria should include timeliness, adherence to aseptic technique, accurate documentation, and appropriate escalation.
- Institutional integration: Incorporate water-safety competencies into annual performance appraisals, clinical competency portfolios, and credentialing processes. Define remediation pathways (targeted supervised practice, repeat assessments) for any deficits.

11.4. Interprofessional

- Joint training: Conduct regular interprofessional exercises including engineers, microbiologists, public health officials, environmental services, and nursing leadership. Shared drills build common language, clarify roles (nurse as clinical liaison and communicator of patient risk), and improve operational coordination for rapid WSP activation, sample logistics, and coordinated community messaging. Regular interdisciplinary morbidity reviews after incidents inform iterative improvements to protocols and training curricula.

12. CASE SCENARIOS

12.1. Scenario 1

Context: Over 24 hours, 10 patients present with profuse watery diarrhoea. Several share a common water source (a community borehole). Two patients show signs of severe dehydration.

Expanded discussion: This cluster pattern is highly suggestive of an acute waterborne outbreak, with Vibrio cholerae, enterotoxigenic Escherichia coli (ETEC), or other enteric pathogens as likely etiologies. The epidemiologic link to a single borehole implicates fecal contamination of a community water supply. Immediate public health actions include rapid case definition, line-listing, and notification to local health authorities for outbreak investigation and water testing (fecal indicator bacteria, residual chlorine, and enteric pathogen PCR where available).

Clinical evidence supports prompt rehydration as the cornerstone of management. For patients with severe dehydration (e.g., hypotension, lethargy, sunken eyes, reduced skin turgor, oliguria), WHO/UNICEF guidelines recommend immediate intravenous rehydration with isotonic crystalloid — Ringer's lactate is preferred when available due to reduced risk of hyperchloraemic metabolic acidosis, with boluses guided by hemodynamic response. For those with moderate dehydration, oral rehydration solution (ORS) using reduced-osmolar formula is effective and reduces mortality. Antibiotics (e.g., single-dose doxycycline in adults for cholera where indicated or azithromycin in pregnant women/children) are adjunctive for severe cholera to shorten duration and reduce stool volume, but should be guided by local resistance patterns and stewardship principles.

Nursing-specific interventions: - Rapid triage using standard dehydration scales and creation of a designated rehydration area to separate infectious cases. - Continuous monitoring of vital signs, hydration status, urine output (hourly for severe cases), mental status, and capillary refill. Maintain accurate intake and output charts. - Establish large-bore IV access, administer prescribed boluses, and titrate maintenance fluids; monitor for signs of fluid overload, especially in elderly or comorbid patients. - Prepare and supervise ORS for ambulatory patients; provide caregiver education on preparation, volume targets, and continued feeding. - Collect and send stool specimens following aseptic technique and specimen-handling protocols; document chain-of-custody and ensure timely transport to the laboratory. - Implement strict contact precautions, hand hygiene, safe waste disposal, and point-of-use water safety measures (chlorination, boiling advisories). Coordinate with environmental health teams for borehole disinfection (shock chlorination) and interim closure if contaminated. Professional insights: Rapid coordination between nursing, laboratory, and public health teams dramatically reduces morbidity. Nurses often lead community education on safe water practices and provide the first line of surveillance through case identification and reporting.

12.2. Scenario 2

Context: A 67-year-old immunocompromised ICU patient develops severe pneumonia two weeks after admission. Legionella urinary antigen is positive.

Expanded discussion: Hospital-acquired Legionnaires' disease in an immunocompromised patient indicates probable nosocomial exposure to aerosolized Legionella from water sources (e.g., taps, sink drains, showers, HVAC systems). Legionella pneumophila urinary antigen testing offers rapid sensitivity for serogroup 1 and can guide early therapy, though culture and PCR from respiratory secretions remain important for epidemiologic typing.

Clinical management should initiate targeted antimicrobial therapy without delay; current evidence and guidelines favor a respiratory fluoroquinolone (e.g., levofloxacin) or a macrolide (e.g., azithromycin) with dosing adjusted for renal function and drug interactions. Supportive ICU care includes oxygen therapy, ventilatory support if needed, hemodynamic monitoring, and management of complications (e.g., respiratory failure, septic shock). Obtain legionella culture/PCR to support source investigation and antimicrobial susceptibility where possible.

Nursing-specific interventions: - Strict adherence to airborne/aerosol-generating procedure precautions during intubation, bronchoscopy, or suctioning; although person-to-person transmission is rare, standard and contact precautions with enhanced respiratory protection during procedures are prudent. - Monitor respiratory parameters closely (SpO2, ABGs), titrate oxygen, manage ventilator settings in collaboration with respiratory therapists, and perform regular oral and airway care to prevent secondary infections. - Ensure timely administration and documentation of antimicrobial therapy, observe for adverse drug effects, and coordinate therapeutic drug monitoring if indicated. - Implement environmental controls: restrict use of implicated showers/sinks, coordinate with facilities management for immediate water system sampling and remediation (thermal eradication, hyperchlorination, or copper-silver ionization as recommended), and contribute to exposure mapping for other patients. Professional insights: Nurses are pivotal in early recognition of nosocomial clusters by noting temporal-spatial patterns of pneumonia. Close liaison with infection prevention and controls, engineering services, and public health enables rapid source control and prevents further cases.

12.3. Scenario 3

Context: After severe flooding, the local municipal water supply is compromised. A temporary field clinic is set up in a community center.

Expanded discussion: Flooding markedly increases the risk of waterborne and vector-borne diseases, disrupts sanitation, and overwhelms healthcare access. Establishing a field clinic requires immediate WASH (Water, Sanitation, and Hygiene) measures, contingency planning for cold chain and medication supply, and robust infection prevention and control (IPC).

Nursing-specific interventions: - Rapid assessment and triage protocols to identify priority conditions (dehydration, wound infections, tetanus-prone injuries, exacerbations of chronic illness). - Ensure safe water for drinking and clinical use via point-of-use treatment (chlorination, solar disinfection, filtration) and verification of residual chlorine levels; secure protected water storage containers and enforce hand hygiene stations with soap or alcohol-based hand rubs. - Set up latrine/toilet facilities with appropriate waste segregation and safe disposal; implement sharps and clinical waste management per public health guidelines. - Vaccination campaigns as indicated (e.g., tetanus toxoid for wound management, measles/rubella for susceptible populations) coordinated with public health. - Deliver wound care, tetanus prophylaxis, and empirical antibiotics for contaminated wounds where indicated; monitor for leptospirosis, cholera, hepatitis A, and other post-flood infections based on syndromic surveillance. - Maintain cold chain for temperature-sensitive medications and vaccines using portable coolers, and ensure secure medication storage and record-keeping.

Professional insights: Nursing leadership in field settings is essential for operationalizing triage, IPC, community education on safe water storage and sanitation, and liaison with emergency response agencies. Documentation, data collection for surveillance, and timely reporting to public health authorities enable resource mobilization and outbreak prevention. Training local volunteers in basic hygiene promotion augments the clinic's reach and sustainability.

Summary

Nurses are essential actors across the continuum of water safety: prevention, surveillance, clinical management, outbreak response, and education. The complexity of waterborne disease prevention demands that nursing roles extend beyond bedside care to active participation in environmental surveillance, Water Safety Plan (WSP) implementation, and public health coordination. Nurses bring clinical insight into risk assessment (identifying vulnerable patient groups such as neonates, oncology and transplant patients, and those with indwelling devices), operational knowledge of point-of-use (POU) device workflows, and frontline experience with early clinical signals that often precede laboratory confirmation. Evidence from hospital-based programs demonstrates that integrated clinical–environmental approaches — for example, routine microbiologic monitoring coupled with targeted patient surveillance — reduce the incidence and duration of water-related healthcare-associated infections (HAIs) and outbreaks by enabling earlier corrective action and targeted prophylaxis.

Key recommendations emerging from this synthesis include:

- Strengthen nursing curricula and continuous professional development to include water-system fundamentals, WSP participation, outbreak response, and POU management. Core content should cover basic hydraulics and plumbing risk points, microbiological indicators (E. coli, Legionella spp., Pseudomonas aeruginosa, heterotrophic plate counts), chemical parameters (residual free chlorine, turbidity), and interpretation of environmental testing. Curricula should integrate competency-based modules on sterile water handling, POU filter installation and maintenance (e.g., 0.2 µm membrane filters, ultrafiltration units), and community-appropriate technologies (ceramic filters, biosand, SODIS). Continuing education should be accredited and include assessment of competency.
- Institutionalize WSPs in hospitals with nursing leadership as a formal component of the team, ensuring frontline insights translate into operational controls. Nurses should hold specific WSP roles (clinical liaison, operational monitor) contributing to hazard analysis, identification of critical control points (e.g., storage tanks, heater settings,

point-of-use outlets), definition of operational monitoring parameters (temperature, residual disinfectant), and prescriptive corrective actions. Nursing leadership ensures that patient-care realities inform acceptable control measures and that nursing workflows enable consistent implementation.

- Embed surveillance linkages between clinical services and environmental testing, with nurses trained and empowered to report and act on early warning signals. Practical interventions include standardized clinical triggers in electronic health records (sudden cluster of gastrointestinal or respiratory syndromes, Legionella-compatible pneumonia), nurse-run environmental sampling protocols, and defined escalation pathways to infection control and facilities engineering. Clinical evidence supports that nurse-led sentinel surveillance shortens time to intervention and reduces outbreak size.
- Promote competency-based training with simulation and interprofessional education to build practical skills for outbreak management and disaster response. Simulations should include tabletop exercises and full-scale drills of Legionella and fecal-contamination scenarios, roles for nursing in triage, POU distribution, patient cohorting, and communication scripts for public messaging. Interprofessional drills improve coordination with microbiology, engineering, and public health partners.
- Operationalize quality improvement with dashboards and KPIs that reflect water safety and nursing performance, and use PDSA cycles for iterative improvement. Suggested KPIs: percentage of outlets with compliant residual chlorine or temperature, rate of positive environmental cultures, time from detection to corrective action, staff competency pass rates, and incidence of water-related HAIs per 1,000 patient-days. Dashboards integrating environmental sensor data and clinical indicators facilitate rapid PDSA cycles.
- Prioritize equity in access to safe water both within healthcare facilities and in community interventions, ensuring POU technologies are sustainable and culturally acceptable. Nursing interventions must include user-centered training for POU maintenance, locally feasible supply chains for consumables (filter cartridges, chlorine), and community engagement strategies. Clinical programs should ensure high-risk patients receive sterile water for consumption and care, and advocate for facility-level investments where home-based interventions are insufficient.

Future research directions include evaluating the impact of nurse-led WSP interventions on patient outcomes through pragmatic trials and implementation science studies, assessing the effectiveness of blended education models (e-learning plus simulation) on nursing competence and retention, and developing validated clinical decision-support tools that integrate environmental sensor feeds, laboratory results, and EHR data to generate risk scores and actionable alerts. Policymakers and healthcare leaders should recognize the centrality of nurses in achieving safe drinking water goals and allocate resources — protected time, professional development funding, and formal roles on WSP and WASH governance committees — to support nursing contributions to environmental health.

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